JOINT OIL ANALYSIS PROGRAM

INTERNATIONAL CONDITION MONITORING CONFERENCE
APRIL 18-22, 2004

PRELIMINARY PROGRAM

ORDER OF EVENTS

Monday, April 19, 2004

ONE. PLENARY SESSION

9:45 a.m. Introductory remarks

10:00 a.m. 1. ***The Navy's oil analysis program—past, present, and future***, Paul Pietsch, Captain, U.S. Navy, Military Director of Propulsion and Power

10:45 a.m. 2. ***Condition based maintenance plus (CBM^{+}): A DoD initiative***, Sarah J. Smith, Colonel, U.S. Air Force, Office of the Assistant Deputy Under Secretary for Defense (OADUSD), Logistics and Materiel Readiness, Maintenance Policy, Programs, and Resources

12:00 noon Lunch (on your own); vendor exhibits open

TWO. OIL ANALYSIS AND EQUIPMENT HEALTH

1:30 p.m. 3. ***The value of the Army oil analysis program to the war fighter***, J. Sanchez, U.S. Army

2:00 p.m. 4. ***Site testing in industry – keep it simple***, M.H. Jones, Swansea Tribology Services Ltd.

2:30 p.m. 5. ***Wear debris in oil lubricated systems – what can it tell us?*** T.J. Nowell,[*†] and A. Curran,[‡] [†]QinetiQ Fuels & Lubricants Centre, [‡]Royal Air Force

3:00 p.m. Break (15 minutes)

3:15 p.m. 6. ***Practical options to ensure maximum lubricant and machinery reliability in a future reduced manpower environment***, C. Leigh-Jones,[*†] T. Kent,[†] and T. Schiff,[‡] [†]Kittiwake Developments Ltd., [‡]ExxonMobil Marine Lubricants – Americas

3:45 p.m. 7. ***The lubrication aspects of machinery health management***, R. Garvey, Emerson Process Management–CSI

4:15 p.m. Break (15 minutes)

4:30 p.m. All JOAP meeting (TSC panel discussion)

5:00 p.m. Program office meetings for the services (NOAP, AOAP, SOAP)

5:30 p.m. Monday's scheduled events end

Tuesday, April 20, 2004

THREE. ANALYSIS OF USED OIL

8:30 a.m. 8. ***After test support in lube analysis, where the action is***, Jack Poley, J4EMS

9:00 a.m. 9. ***Automated system for the determination of acid and base number by differential FTIR spectroscopy***, F.R. van de Voort,[†] J. Sedman[†], D. Pinchuk*[‡] and E. Akochi-koblé,[‡] [†]McGill University, [‡] Thermal-Lube, Inc.

9:30 a.m. 10. ***New, quick, and accurate procedures for oil analysis using FTIR spectroscopy***, F.R. van de Voort,[†] J. Sedman[†], D. Pinchuk*[‡] and E. Akochi-koblé,[‡] [†]McGill University, [‡] Thermal-Lube, Inc.

10:00 a.m. Break (15 minutes)

FOUR. REAL-TIME, ONLINE, AND PORTABLE ANALYSIS OF WEAR DEBRIS*

10:15 a.m. 11. ***Diesel engine portable fluid analyzer: a shipboard CBM enabling technology***, J.E. Tucker,*[†] J. Reintjes,[†] T. Sebok,[§] P. Henning,[¶] and L.L. Tankersley,[□] [†]Naval Research Laboratory, [§]Lockheed Martin, [¶] Foster-Miller Inc., [□]U.S. Naval Academy

10:45 a.m. 12. ***Diesel engine test stand evaluations of on-board oil condition monitoring sensors for U.S. Army ground equipment***, R.E. Kauffman,*[†] L.D. Sqrow,[†] J.D. Wolf,[†] S.C. Moyer,[‡] and J.A. Schmitigal,[‡] [†]University of Dayton, [‡]U.S. Army

11:15 a.m. Lunch (on your own)

1:15 p.m. 13. ***Detection of severe sliding and pitting fatigue wear regimes through the use of broadband acoustic emission***, E.D. Price,[†] A.W. Lees,[†] and M.I. Friswell,[‡] [†]University of Wales Swansea, [‡]University of Bristol

1:45 p.m. 14. ***Real-time, non-invasive, ultrasonic detection of foreign material in process streams***, A.A. Diaz, L.J. Bond,* and T.J. Samuel, Battelle Pacific Northwest National Laboratory

2:15 p.m. 15. ***Application of a microelectromechanical sensor to oil analysis***, A.J. Niksa and R.J. Daley,* Magnus Equipment/Predict

2:45 p.m. Break (30 minutes)

3:15 p.m 16. ***JetSCAN® oil debris analysis system: improving aircraft readiness for the AV-8B Harrier***, B.J. Stoll, U.S. Navy

3:45 p.m. 17. ***Propulsion system diagnostics***, W.J. Hardmann, U.S. Navy

4:15 p.m. 18. ***The U.S. Army's effort to implement an embedded oil analysis sensor***, J.K. Burden,* S. McWhorter, and D. Gratz, ASI-HSV

4:45 p.m. Tuesday's scheduled events end

Wednesday, April 21, 2004

FIVE. X-RAY AND MICROSCOPIC ANALYSES OF WEAR DEBRIS*

8:30 a.m. 19. ***Filter debris analysis – a first line condition monitoring tool***, A. Donahue, GasTOPS Ltd.

9:00 a.m. 20. ***The development of wear debris analysis techniques***, T.J. Nowell, QinetiQ Ltd.

9:30 a.m. 21. ***Finding bearing failure through filter debris analysis***, R. Overman, CMRP Advanced Information Engineering Services, Inc.

10:00 a.m. Break (15 minutes)

10:15 a.m. 22. ***Filter debris analysis by energy dispersive x-ray fluorescence applied to J52 engines***, G.R. Humphrey, Joint Oil Analysis Program Technical Support Center

10:45 a.m. 23. ***Filter debris analysis by energy dispersive x-ray fluorescence applied to F-100 engines***, G.R. Humphrey,* K.V. Hafermalz, M.A. McIntosh, and R. Clayton, Joint Oil Analysis Program Technical Support Center

11:15 a.m. Lunch (on your own)

1:15 p.m. 24. ***X-ray fluorescence: new generation condition monitoring for current systems,*** C.S. Saba,*[†] J. Dell,[‡] and J.D. Wolf,[†] [†]University of Dayton Research Institute, [‡]U.S. Air Force Research Laboratories

1:45 p.m. 25. ***Condition monitoring of aerospace hydraulic and lubrication systems via filter debris analysis***, P. Madhavan,* and G. Rosenberg, Pall Corporation

2:15 p.m. Break (15 minutes)

2:30 p.m. 26. ***An innovative SEM-based algorithm for measuring complex wear particles from oil wetted components***, N.W.M. Ritchie and K. van Beek, ASPEX, LLC

3:00 p.m. 27. ***Health monitoring of oil wetted components via automated electron beam analysis***, K. van Beek and F.H. Schamber, ASPEX, LLC

3:30 p.m. Engineers' forum expert panel discussion**

4:00 p.m. Scheduled program ends

*These sessions are part of our Engineers' Forum. The Engineers' Forum is open to all registered attendees. It includes those papers of special interest to the engineering authorities responsible for weapons system design and maintenance who are tasked with improving the performance of military equipment while lowering the costs associated with operation and upkeep.

**The panel will entertain questions and comments from the floor. Any registered attendee may address the panel.

ABSTRACTS

1 ***The Navy's oil analysis program – past, present, and future***

Paul Pietsch, Captain, U.S. Navy, Military Director of Propulsion and Power, Building 106, 22195 Elmer Road, Unit 4, Patuxent River, Maryland 20670; Phone: 301-757-0416

The address will review the history of the Navy Oil Analysis Program from its inception over 25+ years ago at the Naval Aviation Depot Pensacola to its current configuration and status. Industry trends in equipment health monitoring will be highlighted and their potential impact on the program will be discussed. The following topics will be included: (i) the establishment of the Joint Oil Analysis Program, (ii) the role of NOAP in the Navy's Reliability Center Maintenance Programs, (iii) the current critical safety-of-flight support role being provided to the EA-6B and AV-8 programs, (iv) the current organizational and funding structure, (v) future trends in equipment health monitoring, and (vi) the short- and long-term vision for the NOAP.

2 ***Condition based maintenance plus (CBM$^+$): A DoD initiative***

Sarah J. Smith, Colonel
U.S. Air Force, Office of the Assistant Deputy Under Secretary for Defense (OADUSD), Logistics and Materiel Readiness, Maintenance Policy, Programs, and Resources, Defense Pentagon, Room 3B915, Washington, D.C. 20301; Phone: 703-695-0338, 703-697-7980 (DSN 225-0338, 227-7980); Fax: 703-693-7037 (DSN 223-7037); E-mail: Sarah.Smith@osd.mil

CBM$^+$, itself, is an evolving set of initiatives focused on inserting technology into new and legacy systems that will improve maintenance capabilities or lead to more efficient and effective business processes. It builds on the solid foundation of condition-based maintenance—but expands that foundation to include a wide range of other maintenance and logistics considerations. Preventative maintenance, as we practice it today is effective, but costly. It doesn't necessarily prevent catastrophic failures—and all that they imply, such as very high cost repairs or complete loss of equipment. Nor has it effectively addressed the high false alarm rates we continue to experience—and the attendant costs in labor and material. CBM$^+$, in a broad context, will address challenges such as improving diagnostics and prognostics to support concepts such as anticipatory maintenance. Solid, accurate information can enable smaller footprints of maintainers and logistics support packages. All of this can lead to more efficient operations and better use of our resources. We are building CBM$^+$ on a toolbox full of techniques and approaches. Expanding the amount of information available about what's happening to equipment is a key element. We're looking at more and better sensors, software applications that better diagnose current symptoms, conditions and failures, and logical approaches to predict future failures. We're building expanded serialized item management programs and improving configuration management with tools such as automatic identification technology. We're hopeful that we can use AIT to make maintainers more efficient and to provide them better information across the board. Integrated electronic technical manuals are getting better—they're being integrated with training and are evolving to become more effective job performance aids. Also being looked at are improved portable maintenance aids—replacing paper technical data with electronic aids that are easy to use. But, we note that, for the foreseeable future, the individual maintainer will remain the key to effective maintenance—CBM$^+$ is just trying to help him or her to be even more effective than they've ever been before. The challenge for the CBM$^+$ initiative is to help develop a solid basis of information, knowledge, and experience for the Service and program leadership. With a clear understanding of the effects of CBM$^+$, they can champion the insertion of CBM$^+$ in the design phase, recognize the opportunity to modify legacy systems where appropriate and cost effective, and better appreciate the readiness impacts, logistics benefits, and return on investments to justify their cost of CBM$^+$ implementation.

3 ***The value of the Army oil analysis program (AOAP) to the war fighter***

Jose Sanchez
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The Army Oil Analysis Program (AOAP) has remained a major Army maintenance program for over 40 years. Objectives of the program are to improve operational readiness of Army equipment, promote safety, detect impending component failure, and conserve resources. AOAP laboratories are equipped with the latest testing technology, and the program provides significant benefits to its customer and to the Department of Defense. Several agencies within the Defense Department have reviewed the Army Oil Analysis Program (AOAP) in order to determine the value and effectiveness of this program to the war fighter. The main purpose for the studies is to optimize the AOAP by reducing the labor hours for both the maintainer and the AOAP laboratory personnel. In November 1997, the Chief of Staff of the Army directed the Army G-4 to review the AOAP and make it more efficient. Since then, the Army Audit Agency, the Logistics Integrated Agency, and others, have studied the AOAP in detail. In addition, an economic analysis was performed by the University of Alabama. The different agencies that conducted the studies determined that the current structure of the AOAP was fragmented and suboptimal. Subsequently, the Army oil analysis program manager conducted a review and assessed alternatives that led to a restructuring plan for the AOAP. The end goal is to transform the program under the Logistics Transformation Task Force in order to maximize support to the war-fighter and advance testing technologies forward to the unit level, support the Army's vision, and reduce the logistics footprint on the battlefield by incorporating online and inline embedded sensors. During the presentation, details of the studies will be presented to show that all of the agencies that conducted the studies did in fact find tremendous value in the AOAP.

4 ***Site testing in industry – keep it simple***

Mervin H. Jones
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Over the last ten years there has been a proliferation of site test equipment. Individual instruments that measure viscosity, water, base and acidity; particle counters; and wear debris monitors are some of the most common examples. These instruments are also often batched into mini laboratories. Papers are presented at nearly every maintenance and condition monitoring conference—this conference included—that quote success stories of both their individual benefits and their combined benefits when used in on-site laboratories. What is never presented however, are the cases where an instrument, instruments, or mini laboratories have been purchased and, after a short interval, are no longer in use and often locked away collecting dust—an all too often occurrence. The question then has to be asked: "has the conference or lecturer or salesman been too effective?" An attempt will be made to explain the skepticism about on-site testing and the mini laboratory philosophy in the following arguments. These arguments apply mainly to the small to medium size engineering companies (SME) although larger companies often also fall into a similar trap. Exceptions, however, are the military services—army, navy, and air force—that require instant answers for tactical and logistic reasons.

5 ***Wear debris in oil lubricated systems – what can it tell us?***

Tim J. Nowell,*† and A. Curran‡
†QinetiQ Fuels and Lubricants Centre, Cody Technology Park, Ively Road, Farnborough, Hampshire GU14 0LX United Kingdom; ‡Assistant Directorate Air Integrity Monitoring, Block L, Royal Air Force Wyton, P.O. Box 70, Huntingdon, Cambridgeshire PE17 2PY United Kingdom; Phone: 44-0-1252-374718 (TN), 44-0-1480-52451, ext. 6387 (AC); E-mail: tjnowell@ QinetiQ.com

All oil-wetted systems produce debris and this function can be a vital part of a condition monitoring program (CMP) of a transmission or an engine. By capturing debris, either by in-line filters or magnetic detection plugs and analysing the composition and morphological attributes a lot of valuable information can be gleaned. Careful interpretation of such data can indicate the types of wear modes active within a lubrication system. By understanding the implications of wear and relating these to a particular component, potentially critical defects within a system can be identified. The operator is then able to take appropriate maintenance action to prevent catastrophic failure. This paper examines how understanding the basic principles of wear debris analysis can be utilised as a powerful tool in a CMP. And how, by relating ferrous alloy wear debris to events in an oil-lubricated system during the life of a component, the operator can benefit in terms of safety, operational availability and cost.

6 ***Practical options to ensure maximum lubricant and machinery reliability in a future reduced manpower environment***

Chris Leigh-Jones*† and Thomas A. Schiff‡
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Future military machinery platforms assume a greatly reduced manpower requirement. Meeting this challenge will mean reviewing lubricant selection and monitoring systems to provide a maximum reliability and availability with minimum manpower. This paper will show that combining novel on-line oil analysis techniques covering oil and machinery condition with a well balanced "quality reserve" lubricant designed for a specific application will yield the optimum equipment reliability. To achieve this with minimal manpower and material resources, the lubricant must compensate for the harsh hills and valley's today's equipment will endure. Early detection of an impending problem through on-line monitoring of selected parameters, predictive maintenance techniques and the lubricant's performance will all have a dramatic impact on equipment's life cycle costs. This paper will illustrate how commercially available lubricants will clearly outperform standard specification lubricants through real life examples, as well as glassware testing. This paper offers a pragmatic and realistic strategy for lubrication of future machinery platforms.

7 ***The lubrication aspects of machinery health management***

Ray Garvey
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This presentation addresses the lubrication aspect of machinery health management. It is divided into six parts. *(1) How are priorities set?* Identify a few mechanisms that cause most of the abnormal wear leading to machinery failure. *(2) What is a lubrication program?* Discuss ten elements of an effective lubrication program, including lubricants, contamination control, and monitoring. *(3) How should oil be analyzed?* Understand the reasons for choosing particular tests and the options for getting the analysis performed. *(4) How is a lubrication program managed?* Find tools that assist in managing oil analysis and lubrication data. *(5) What kinds of lubricants are there?* Learn about various mineral and synthetic lubricants and their uses. *(6) Where do we begin?* Find out what to do next, whether a program is just getting started or continually improving.

8 ***After test support in lube analysis, where the action is***

Jack Poley
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Testing lubricants for wear debris, contamination and degradation has arguably reached a *de facto* state. Most of the routine tests are highly similar in terms of methodology and reporting formats. Even ferrography, electron microscopy and other less frequently applied tests are usually invoked for similar objectives. Although there are increasingly sophisticated testing instruments and processes, parameters investigated remain nearly the same, thus testing is primarily reduced to a commodity with the basic requirements of accuracy in testing and timeliness in returning data to the client. What has not become standard is the evaluation of test data in terms of determining limits and trends for flagging data and, more importantly, the interpretation or conclusion drawn from test results. Additionally there is a need to have the capability to assess true return on investment from the application of lube analysis. This paper describes a software solution, consisting of a number of specific modules and applications, that addresses virtually all the issues associated with rendering accurate diagnoses and maximizing return on investment from lube analysis program costs:(1) diagnostic algorithms that are continually updated by asfound conditions and feedback input, and statistical data mining in several formats, (2) statistical updating of the numerical traps for flagging data, inclusive of feedback considerations, (3) decision-making data for equipment acquisition and deployment and various other types of management summaries, (4) an ROI model for calculating a program's true value and financial return, incorporating cost and utility data, and utilizing statistical modeling based on reliability centered maintenance.

9 ***Automated system for the determination of acid and base number by differential FTIR spectroscopy***

F.R. van de Voort,[†] J. Sedman[†], D. Pinchuk,*[‡] and E. Akochi-koblé[‡]
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FTIR spectroscopy is a rapid instrument-based technique that has been widely employed for lubricant condition monitoring purposes. Relative changes in various indicators of oil condition, ranging from soot to nitration may be determined employing JOAP procedures and guidelines. FTIR spectroscopy also has the potential to quantitatively measure parameters such as acid number (AN), base number (BN), and water in oil.An automated AN/BN Analyzer capable of analyzing >60 samples/hour has been developed. The system employs FTIR methodology for the determination of both AN and BN through the use of signal transduction and differential spectroscopy. The advantages of this advancement include both (a) the elimination of the need for a reference oil, commonly associated with FTIR lubricant analysis, and (b) reduced sample viscosity allowing for higher sample throughput. By comparison with conventional ASTM titrimetric methods for AN and BN determination, these new FTIR methods have the advantages of utilizing smaller sample sizes, thereby requiring less solvents and reagents. These rapid, accurate, and highly reproducible FTIR methods represent a major progression in lubricant analysis.

10 ***New, quick, and accurate procedures for oil analysis using FTIR spectroscopy***

F.R. van de Voort,[†] J. Sedman[†], D. Pinchuk,*[‡] and E. Akochi-koblé[‡]
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Aging instruments predominate in the oil conditioning field based on analysis using the JOAP protocol. Although the JOAP protocol allows a relatively simple means of general assessment of oil condition, the instrumental throughput is relatively slow owing to peristaltic pumps to load viscous oils followed up by line rinsing with solvents. This in itself renders the analysis a tedious and solvent intensive process. Given that high oil viscosity causes costly bottlenecks in FTIR condition monitoring analysis throughput, it seems logical the solution would lie in reducing the viscosity of the oil sample prior to analysis. This can readily be attained by diluting the sample with kerosene marked (spiked) with a known amount of an IR quantifiable marker. The amount of kerosene added to an oil for dilution can be accurately determined by the 'residual' marker in the sample. Knowing the exact amount of kerosene added allows one to subtract kerosene's spectral contribution to the mixture therefore leaving only the oil spectrum to contend with. This oil spectrum -in turn- can be multiplied by the dilution factor to "reconstitute" the original oil spectrum to that which one would have obtained had the oil sample been analyzed without prior dilution. The net effect of implementing such procedures is that one can run a diluted, low viscosity sample, while obtaining exact spectral data for the undiluted oil.

11 ***Diesel engine portable fluid analyzer: a shipboard CBM enabling technology***

John E. Tucker,*[†] John Reintjes,[‡] Tom Sebok,[§] Pat Henning,[¶] and Larry L. Tankersley[□]
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Oil sample analysis often suffers in a shipboard environment due to the long time it takes to deliver a sample to an analysis lab, and to get the results back to the ship. Many times, when the results arrive back to the ship, a piece of equipment has failed and an opportunity was lost to identify it prior to the failure. Having the capability to perform an on-site evaluation of machinery health through a comprehensive machinery fluid monitor significantly improves the effectiveness of equipment inspections. The Naval Research Laboratory with Lockheed-Martin and Foster-Miller under an ONR Tech Solutions program, have combined several advanced diagnostics in a single instrument package to provide an on-site comprehensive oil monitor for use by diesel engine inspectors. This instrument combines the LaserNet Fines wear debris monitor, the FluidScan oil condition monitor and a compact viscometer and is designed to be used on-site, away from a laboratory environment. The LaserNet Fines instrument determines the type, severity and rate of progression of mechanical faults by measuring the size distributions, rate of production and the morphological analysis of debris particles in fluids. It has been used to monitor a wide range of equipment including diesel engines, cranes and hydraulic system. The FluidScan instrument monitors fluid properties through the infrared transmission of the fluid and has been installed inline on several U.S. Navy ships. It monitors fluid properties such as water, soot, oxidation, nitration, sulfation, glycol, anti-oxidation depletion and TBN in diesel lubricating oil. Software was developed to control each instrument and to combine their results in a combined report assessing machinery health.We present results obtained by the diesel inspectors during an evaluation period of shipboard oil samples.

12 ***Diesel engine test stand evaluations of on-board oil condition monitoring sensors for U.S. Army ground equipment***

Robert E. Kauffman,*† Larry D. Sqrow,† J. Douglas Wolf,† Steve C. Moyer,‡ and Joel A. Schmitigal‡

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This paper describes the second year of a project to develop an inexpensive, compact on-board sensor system for condition monitoring the in-service diesel engine oils of U.S. Army vehicles and ground support equipment. A high mobility multi-wheeled vehicle (HMMWV) diesel engine test stand was used to evaluate the capabilities of different sensors to monitor four specific changes in oil condition: soot accumulation, accelerated oxidation, coolant leaks and fuel dilution. The HMMWV diesel engine was selected for this work based on its low cost and wide use by the Army. The four diesel engine test stand evaluations described herein determined that two different types of sensor systems would be suitable for on-board use. Conductivity sensors and a battery operated electronics package were attached to a HMMWV diesel engine dipstick to produce the first sensor system. The "dipstick sensor system" could be used in place of the current engine dipstick to monitor oxidation, coolant contamination, fuel dilution and fluid level of in-service oil before engine start-up or directly after engine shut down. A magnetic plug, manual or electronic, could be used in place of the oil drain plug to monitor the production of magnetic (iron) debris. The other sensor system used a suite of sensors incorporated into an oil radiator hose by-pass to monitor soot accumulation, oxidation, coolant contamination, magnetic wear debris production and fuel dilution of in-service oils during engine operation. The suite of sensors included a dielectric sensor, two different conductivity sensors, a magnetic plug and an infracal soot sensor.

13 ***Detection of severe sliding and pitting fatigue wear regimes through the use of broadband acoustic emission***

E. D. Price,† A. W. Lees,† and M. I. Friswell,‡

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Acoustic emission techniques have been used to monitor severe sliding and pitting fatigue processes during four-ball testing. Results are presented that arose from a collaborative programme between the Naval Research Laboratory (Washington, D.C.) and the University of Wales–Swansea, sponsored by the U.S. Office of Naval Research. The ultimate aim of the research is to develop a systematic fusion technology approach to condition-based maintenance of wear-related surface distress of critical components in naval air and surface combatant engine and transmission systems. The principal monitoring techniques utilized in the investigation comprise acoustic emission, vibration analysis and wear debris analysis; however, only AE results are included here. A custom data acquisition system was developed using a novel approach to collect AE signals. Post-test analysis of the data, in the frequency domain, demonstrates the advantage of analysing continuous AE and not just AE pulses.

14 ***Real-time, non-invasive, ultrasonic detection of foreign material in process streams***

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During manufacturing or processing, the presence of foreign material in a process stream can be a significant problem. The Pacific Northwest National Laboratory (PNNL) has developed a method for real-time, non-invasive ultrasonic detection of foreign matter in both homogeneous and inhomogeneous process streams. A novel, off-angle ultrasonic scattering approach is used as the basis for the detection methodology involving measurements of scattered ultrasonic energy from a configuration of pitch-catch transducers that are coupled to the process stream. The scattered ultrasonic energy from these pulses are analyzed in terms of time-of-flight, amplitude and frequency content to extract information about the process stream and rapidly detect foreign matter during the manufacturing process. Examples will be presented describing examinations of process streams with a focused sound field that spans a portion of the stream. The off-angle scattering response to the interrogating sound field is then detected with a plurality of spaced receivers, with the presence of foreign material determined from the received response. This talk will focus on technical aspects of the detection protocol, applications in the food processing industry, and how the methodology might apply to condition monitoring of fluids and oils.

15 ***Application of a microelectromechanical sensor to oil analysis***

Andrew J. Niksa and Raymond J. Daley*
Magnus Equipment/Predict, 9555 Rockside Road, Cleveland, Ohio 44125, Phone: 216-642-3223, E-mail: rjdalley@predictusa.com

The paper will present a new microelectromechanical oil sensor (MEMS) and its application. The sensor is designed to detect changes in internal combustion engine lubricating oils that are a result of wear and contamination. A unique combination of data is collected from the sensor rather than a single measurement. The theory of operation will be discussed. Data results and correlation to oil condition will be shown. Trending of the data is more valuable as the sensor is on-line with the capability of monitoring continuously.

16 ***JetSCAN® oil debris analysis system: improving aircraft readiness for the AV-8B Harrier***

Brian J. Stoll, Engine In-Service Engineering Branch 1 (AIR-4.4.8.1), AV8 Fleet Support Team – Propulsion (AV8FST.3), Naval Air Systems Command, PSC Box 8021 (Code 4.4.8.1), MCAS Cherry Point, North Carolina 28533-0021; Phone: 252-464-9865 (DSN: 451-9865); Fax: 252-464-7147 (DSN: 451-7147); E-mail: stollbj@navair.navy.mil

The oil system monitoring (OSM) program for the AV-8B Harrier's F402-RR-408A/B engines, includes analysis of debris captured by two magnetic chip detectors. Discovery of a large particle requires the particle to be analyzed to determine its elemental composition, which can then be cross-referenced to material specifications and possible source components within the engine oil system. The criticality of this inspection demands the aircraft remain grounded pending the laboratory analysis results. Aircraft within close proximity to a laboratory have typically experienced a downtime of 24 hours. However, aircraft aboard ship or forward deployed have historically experienced downtimes of seven to ten days due to sample transit times to the nearest laboratory. The loss of an aircraft for that length of time is detrimental to fulfilling the operational requirements of the forward deployed or shipboard activities. To answer the need for increased readiness, the AV8 fleet support team, in conjunction with Data Systems & Solutions, tested and approved the use of the JetSCAN® oil debris analysis system. The JetSCAN® is a transportable, automated SEM/EDX machine that requires minimal training. It has the capability of automatically measuring (geometrically) and performing an EDX analysis of identified particles, and then determine the most likely material specification from its database of materials. Use of the JetSCAN® has significantly reduced the inspection time and has eliminated the requirement of a laboratory near an aircraft operating location. Information on the benefits of this technology, its developmental evolution for the F402 series of engines, its success during Operations Enduring Freedom and Iraqi Freedom, and future plans for more extensive use within the F402 engine OSM program will be presented.

17 ***Propulsion system diagnostics***

William J. Hardmann
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An overview of NAVAIR propulsion system diagnostic programs will be presented. Topics will include current fixed and rotary wing diagnostic systems, a brief overview of *joint strike figher prognostics and health management*, as well as the results of some seeded fault testing. The Defense Advanced Research Projects Agency (DARPA) prognosis materials based research program will also be covered. Finally, a data warehousing and mining effort known as *integrated aircraft health management* will be discussed as it relates to maximizing utilization of collected operational and maintenance data.

18 ***The U.S. Army's effort to implement an embedded oil analysis sensor***

Judy K. Burden,*[†] R. McWhorter,[‡] and Dawn M. Gratz[§]

[†]Contract Support PM-TMDE ACED, Analytical Services, Inc., 689 Discovery Drive, Suite 300, Huntsville, Alabama 35806, Phone: 256-890-0083 ext. 151; Fax: 256-890-0242; E-mail: burdenj@asi-hsv.com; [‡]Director of Technology and Acquisition, Army Oil Analysis Program, Logistics Support Activity, Bldg. 3661 Ajax Road, Redstone Arsenal, Alabama 35898; Phone: 256-955-6661 (DSN 645-6661); Fax: 256-876-9344 (DSN 746-9344); [§]Army Common Embedded Diagnostics, SFAE-CSS-ME-T-A; Phone: 256-955-6884 (DSN 645-6884); Fax: 256-955-6361 (DSN 645-6361); E-mail: dawn.gratz@us.army.mil

The focus of this effort is to find a commercial-off-the-shelf (COTS), in-line oil condition sensor suitable for use in Army tactical, wheeled and track vehicles. The in-line oil condition sensor will notify the soldier in the field that oil maintenance is required. The anticipated benefit is the reduction in labor hours for both the maintainer and AOAP lab personnel expended in drawing, shipping, and analyzing oil samples. The main thrust is to support the Army's transition from reactive maintenance to proactive maintenance, from demand logistics to anticipatory logistics, and eventually from diagnostics to prognostics. The sensor will visually notify the soldier by different colored lights when the condition of the oil merits changing due to depleted additives or out of tolerance total acid number merits testing due to contaminant detection, or simply merits replenishing due to low oil level is low. The sensor needed is self-calibrating and with built in memory for use in trend analysis. The output data will be made available to the Army's Surface Health Usage Monitoring System (SHUMS) for further analysis via one of the standard buses, such as J1708, 1553 or 1939. A cost analysis performed by the Assistant Product Manager, Army Common Embedded Diagnostics (ACED), Office of the Product Manager, Test Measurement and Diagnostic Equipment (PM TMDE) will be included.

19 ***Filter debris analysis – a first line condition monitoring tool***

Aiden Donahue
GasTOPS Ltd., 12 AMS Shearwater, Nova Scotia, Canada; Phone: 902-460-1011 ext. 1802; E-mail: seaking@netcom.ca

Mechanical systems begin to wear as soon as they are put into operation. Monitoring the wear debris shed by a mechanical system provides valuable insight into its health. Historically, wear debris generation has been typically monitored by various oil analysis techniques such as ferrography and spectrometric oil analysis. With oil wetted systems moving toward finer and finer filtration, the wear debris normally monitored by these techniques is no longer left in the oil but is now trapped by the system's filter. Lube oil filters and their efficiency is not well understood and it has a big affect on debris capture efficiency and the type of debris that is captured by the filter. Filter debris analysis (FDA) has been around for almost 20 years. It has its origin in Canada with the Defense Research Establishments and a project to address main gearbox failures on the Sea King helicopter back in the mid-1980s. The project was so successful that the technique continued to develop and became an integral part of the helicopter's maintenance program. The FDA program eventually migrated to other aircraft, engines and fuel filters. It has evolved from a very long and manpower intensive, qualitative and subjective technique to a simple, quick and accurate technique for determination of a system's health. Filter debris analysis is now a deployable first line condition monitoring technique used around the world to determine the health of aircraft oil wetted components. The presentation will discuss wear debris in mechanical systems, filtration and filter efficiency and the application of Filter Debris Analysis to determine equipment health.

20 ***The development of wear debris analysis techniques***

Tim J. Nowell
QinetiQ Ltd., Fuels & Lubricants Centre Cody Technology Park, Ively Road, Farnborough, Hampshire GU14 0LX United Kingdom; Phone: 44 (0) 1252 374718; E-mail: tjnowell@QinetiQ.com

Morphological wear debris analysis is an equipment health monitoring technique used to identify incipient failures of components within engine or gearbox lubrication systems. Although a vital tool in any condition-monitoring program, wear debris analysis can be tedious and time consuming, relying heavily on the experience of the operator. The subjectivity of operator's judgements also means that diagnosis may not be consistent between operators. Variations will also occur with respect to the training and experience of the operators. In addition, while people are very good at delivering qualitative descriptions, they perform poorly when asked to quantify the factors contributing to their judgments. Within the Royal Air Force, wear debris analysis is performed by technicians based at Early Failure Detection Centres (EFDCs). It has long been recognised that the fluid staffing policy operated by the Air Force means that the situation can arise where an EFDC operator with limited experience can be placed in a position of having to make critical maintenance decisions. This paper examines how these problems associated with wear debris analysis have been addressed and the related development of methodologies to enable Royal Air Force EFDC technicians make an objective assessment of equipment health.

21 ***Finding bearing failure through filter debris analysis***

Richard Overman
CMRP Advanced Information Engineering Services, Inc., 340 Corporate Way, Suite 100, Orange Park, Florida 32073; Phone: 904-264-1440; E-mail: rich.overman@ai.engsvcs.com

Bearings give many different warnings when they are going bad. Some of these warnings include increased vibrations, noise, and the loss of bearing material. Each warning can be detected by different techniques. Vibration can be detected by vibration analysis, noise by listening, and bearing material loss by filter debris analysis (FDA). Vibration analysis is commonly used and well-known, and listening for noise is often too late. On the other hand, FDA is not well-known, but it is a powerful tool. This paper reports on an analysis of a jet engine bearing and the use of FDA to detect impending failures. The paper describes the FDA process, bearing failure stages, and how all of this information was pulled together through reliability-centered maintenance analysis to develop a cohesive function preservation strategy.

22 ***Filter debris analysis by energy dispersive x-ray fluorescence applied to J52 engines***

Gary R. Humphrey
Joint Oil Analysis Program Technical Support Center, 85 Millington Road, Pensacola, Florida 32508; Phone: 850-452-3191 ext. 105; E-mail: ghumphrey@joaptsc.navy.mil

The Joint Oil Analysis Program Technical Support Center (JOAP-TSC) has developed a technique to analyze the debris from in-line jet engine oil filters by energy dispersive x-ray fluorescence (FDA-EDXRF). Six beta prototype instruments were manufactured under a Productivity Reliability Availability and Maintainability (PRAM) project that are capable of performing FDA-EDXRF in an automated mode. J52 engines were suffering from what appeared to be sudden, catastrophic failures – where the root cause of the failure began with the lack of lubrication in the 4½ bearing area followed by fracturing of the 4½ bearing cage. Initially, analysis of oil samples by rotrode emission spectroscopy (RDE) did not indicate the failure mode. FDA-EDXRF was employed to establish wear limits for the debris extracted from engine oil filters; particle count wear profiles were developed from the debris extracted from the engine oil filters and abnormal bearing wear could be diagnosed. Initially, filter debris obtained from J52 filters that indicated abnormal amounts of bearing wear were also analyzed by Pratt & Whitney Aerospace laboratory using a scanning electron microscope (SEM). The SEM results confirmed the presence of bearing wear. Subsequent teardowns of a portion of the engines having abnormal bearing wear had fractuered 4½ bearing cages. This paper will outline how the JOAP-TSC beta prototype instruments and FDA technology have kept the J52 fleet flying.

23 ***Filter debris analysis by energy dispersive x-ray fluorescence applied to F-100 engines***

Gary R. Humphrey,* Kristina Hafermalz, Mark A. McIntosh, and Robert Clayton
Joint Oil Analysis Program Technical Support Center, 85 Millington Road, Pensacola, Florida 32508; Phone: 850-452-3191 ext. 105; E-mail: ghumphrey@joaptsc.navy.mil

The Joint Oil Analysis Program Technical Support Center (JOAP-TSC) was awarded a project from the U.S. Air Force Productivity, Reliability, Availability, and Maintainability (PRAM) office. The project entailed automating the removal of debris from engine oil filters, presenting the debris for energy dispersive x-ray fluorescence (EDXRF) analysis and provide software to manipulate the x-ray hardware and report EDXRF analyses. The JOAP-TSC put in place the requirements to construct beta prototype instruments with the above capabilities. PRAM beta prototype instruments were located at LUnited Kingdome AFB and Seymour-Johnson AFB to analyze filters from F-100 engines. The JOAP-TSC applied filter debris analysis using energy dispersive x-ray fluorescence analysis (FDA-EDXRF) to profile F-100 engines. Data from the F-100 engine FDA-EDXRF profile was used to indicate abnormal wear. Engines that indicated abnormal and normal wear by FDA-EDXRF metrics were researched using the AF maintenance database. The results demonstrated an excellent correlation with the wear found in F-100 engines.

24 ***X-ray fluoresence: new generation condition monitoring for current systems***

Costandy S. Saba,*[†] Jon Dell,[‡] and J. Doug Wolf [†]

[†]University of Dayton Research Institute, 300 College Park, Dayton, Ohio 45469-0166; [‡]AFRL/PRTM, U.S. Air Force, Air Force Research Laboratories (PRTM), Wright Patterson AFB, Ohio 45433-7103; Phone: 913-255-3141, DSN 785-3141 (CSS); E-mail: costandy.saba@wpafb.af.mil

An analytical tool been developed that modifies/combines known x-ray fluorescence and transmission analysis and video imaging techniques for fast, automated analysis of lubrication system wear debris. It is applicable to debris taken from magnetic chip detectors and oil samples of gas turbine engines. Procedures for isolating, mounting, and analyzing the wear debris for multi-samples have been developed. This analytical technique can accomplish the task currently being done on debris and oil samples from military gas turbine engines with two techniques using costly instruments. Debris from magnetic chip detectors is being analyzed at some locations with expensive scanning electron microscopes. However, XRF can analyze chip detector debris for failure detection as effectively as SEM but at much lower cost. XRF has the added advantage of detecting the presence of metallic alloys of interest at a greater depth in the debris than the SEM system. Oil samples are also being analyzed with atomic emission spectrometers that require a cumbersome field wide coordinated calibration program. While AE spectrometers are limited to wear debris particle size to less than 10 μm, this approach can effectively detect impending failure better than AES due to its capability of detecting and analyzing the full range of debris sizes expected without upper size limitations.

25 ***Condition monitoring of aerospace hydraulic and lubrication systems via filter debris analysis***

Puliyur Madhavan* and Gary Rosenberg
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Evaluation of the composition of filter debris as a diagnostic tool to monitor the condition of fluid systems has gained prominence over the last decade, and techniques such as x-ray fluorescence spectroscopy have been employed to determine the chemical composition of engine lube filter debris, necessary for diagnosis of potential lube system component wear modes, and even some modes of fluid degradation. In this paper, the use of a diagnostic filter, coupled with a custom filter debris analyzer, designed for effective, convenient debris monitoring in fluid systems, to monitor debris in aerospace hydraulic and lubrication systems is discussed. The diagnostic filter has several configurations that allow for convenient analysis of the captured debris. The analysis of the chemical composition of filter debris is accomplished with a custom designed, portable filter debris analyzer, based on x-Ray fluorescence spectroscopy, currently in the beta prototype testing stage. The debris analyzer is custom designed to accommodate sections of the diagnostic filter. In its final configuration, the analyzer software will allow users to develop their own system specific database/expert system for debris analysis. Results from the use of the diagnostic filter/debris analyzer to evaluate debris from aircraft hydraulic systems and helicopter transmission lube systems during on-ground testing are presented and discussed to illustrate the value of the debris monitoring system for on-ground testing. This allows for qualification of manufacturing/assembly processes with respect to built-in debris. The benefits of the debris monitoring system, described above, can also be realized for hydraulic and lubrication systems during service operation.

26 ***An innovative SEM-based algorithm for measuring complex wear particles from oil wetted components***

Nicholas W.M. Ritchie and Kai van Beek
ASPEX, LLC, 175 Sheffield Drive, Delmont, Pennsylvania 15626; Phone: 724-468-5400 ext. 262; E-mail: nritchie@aspexllc.com

Early in the days of computer controlled scanning electron microscope (SEM) technology, a particle-sizing algorithm was developed which took advantage of the electron-beam nature of the SEM to provide both fast and accurate measurements of simple particles. This algorithm, called the rotating chord algorithm, took advantage an SEM's ability to raster the electron probe along arbitrary axes and to dynamically adjust the step size between pixels. In recent years, many SEM manufacturers have drifted away from this algorithm towards a frame-based image analysis. Frame-based techniques are slower and less precise but are more capable of handling complex particle shapes and are simpler to implement. By using frame-based analysis, these vendors lost many of the advantages of an electron beam instrument. We will present a novel and innovative algorithm that leverages the capabilities of an SEM to combine the advantages of the rotating chord and the frame-based image analysis techniques. This algorithm is both faster and more precise than typical frame-based techniques. Like the rotating chord algorithm is capable of analyzing particles as they are discovered thereby minimizing the likelihood of losing small particles. To demonstrate how this algorithm is particularly beneficial for oil wear debris analysis, we will present speed and precision data collected on the complex particles characteristic of wear debris from oil-wetted components.

27 ***Health monitoring of oil wetted components via automated electron beam analysis***

Kai van Beek and Frederick H. Schamber
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Diagnostic analysis of debris extracted from an oil system can provide an early warning of incipient failure, and is particularly valuable when such determination can be accurately conducted under field conditions. Understanding the source and nature of such particulate contaminants is critical for accurate risk assessment. When an optimized electron beam analysis tool performs automated microscopic examination, it provides not only distributions of particulate material by size and shape, but also accurate classification by composition. Detailed images of individual particles are also readily obtained and can be a great aid to source evaluation. Recent advances in instrument form factors, enabling technologies, and user interactions now bring the power of SEM/EDX technology to locations and environments previously unthinkable. Requiring only a standard electrical outlet, an automated SEM/EDX system will be described that can be rolled or forklifted into place and be operational in under ten minutes

Key Underline denotes the presenting authors.
*Asterisks denote the corresponding authors.

TRAINING COURSES

Training courses will be held in the Beachside Resort connected to the Hilton via a covered walkway.

Monday morning, April 19, 1:00 p.m. – 5:00 p.m.

1 An overview of oil analysis techniques, Dan Anderson, Spectro, Inc.

Tuesday morning, April 20, 8:00 a.m. – 12:00 noon

2a Basic error analysis and statistics, Daniel C. Harris, Ph.D., U.S. Navy

Tuesday afternoon, April 20, 1:00 p.m. – 5:00 p.m. (concurrent classes, both cannot be taken)

2b JOAP correlation statistics, Marilyn Squalls, JOAP TSC

2c Filter debris analysis, Gary Humphrey, JOAP TSC

Wednesday morning, April 21, 8:00 a.m. – 12:00 noon

3a Infrared spectroscopy and spectral interpretation, Timothy W. Collette, Ph.D., Environmental Protection Agency

Wednesday afternoon, April 21, 1:00 p.m. – 5:00 p.m.

3b Oil analysis on the Digilab FTIR spectrometer, Mike Fuller, Ph.D., Digilab

Thursday morning, April 22, 8:00 a.m. – 12:00 noon

4a Atomic emission spectrometry, Edward T. Urbansky, Ph.D., JOAP TSC

Thursday afternoon, April 22, 1:00 – 5:00 p.m. (concurrent classes, both cannot be taken)

4b Oil analysis on the Spectroil M, Bob Yurko, Spectro, Inc.

4c Ferrography, Ray Dalley, Predict

See course description and instructor information on the following pages.

COURSE DESCRIPTIONS AND INSTRUCTORS

An overview of oil analysis techniques

Course no. 1 | Mon., April 19, 1:00 p.m. | Daniel P. Anderson
$15 | anderson@spectroinc.com

About the course

There are a variety of analytical instruments available to answer the two main questions posed by oil analysis, namely, the condition of the machine and the condition of the lubricant. This workshop will focus primarily on the instruments and techniques for measuring wear and contaminant particles, with minor emphasis on determining lubricant condition since this topic is covered more extensively in other workshops being held this week. Topics to be covered include atomic emission spectrometry (i.e., rotrode, inductively coupled plasma), ferrography, particle counting, laser net fines, and the behavior of large particles in oil.

About the instructor

Daniel P. Anderson graduated from MIT in 1970, majoring in materials science and metallurgy. He worked for seven years as an aerosol scientist and instrumentation engineer before beginning his career in tribology with the Foxboro Company. He joined Foxboro in 1977 as lab manager of the ferrography product group. He prepared the *Wear Particle Atlas (Revised)* in 1982, still the primary reference on ferrography. He moved to Cleveland in 1984 to become lab manager when Predict Technologies was first started by Standard Oil of Ohio. He joined Spectro, Inc., manufacturer of oil analysis spectrometers, in 1986, and has traveled extensively— promoting and installing instruments and turnkey laboratories for predictive maintenance by oil analysis. He is the inventor of rotrode filter spectroscopy. In 1991, he was one of the founders of National Tribology Services, a commercial oil analysis laboratory, recently sold to the Bently Nevada Company. He is now vice president of sales for Spectro Inc. in Littleton, Massachusetts.

Basic error analysis and statistics

Course no. 2a | Tues., April 20, 8:00 a.m. | Dan Harris, Ph.D.
$25 | daniel.harris@navy.mil

About the course

This course will introduce the student to data analysis. We begin with the statistical treatment of a single set of data, estimating the uncertainty in an individual measurement, and computing the uncertainty in the average. Next, we compare average values to determine if they really are different and propagate the errors in their ratios and differences. Finally, we move onto two-dimensional data analysis, where we find the best fit line using unweighted linear regression. Students will be taught to use a spreadsheet and a scientific calculator to analyze laboratory data. A TI-36X calculator is required and provided for this course; its cost is built into the course fee.

About the instructor

Daniel C. Harris is a senior scientist in the chemistry division of the research department at the Naval Air Systems Command, China Lake, California. Dr. Harris is the author of the most widely used analytical chemistry textbook, *Quantitative Chemical Analysis* (6th edition, W. H. Freeman, 2002). In an earlier life, he taught chemistry at the University of California at Davis and at Franklin and Marshall College in Pennsylvania. He has degrees in chemistry from Caltech and Massachusetts Institute of Technology. His primary responsibilities in the Defense Department are in research, development, and engineering of optical window materials.

JOAP correlation statistics

Course no. 2b | Tues., April 20, 1:00 p.m. | Marilyn S. Squalls
$15 | msqualls@joaptsc.navy.mil

About the course

We will present statistical terms that are routinely encountered and give examples of how statistics are use to calculate a laboratory's correlation score for performance on spectrometric analysis. To provide some hands-on experience, we will work with actual data. Students will have the opportunity to determine the passing range for any element from the February 2003 correlation, so bring your score sheet from February 2003. We will do the calculations and show you why you received a *fail* or a *pass* for that element.

About the instructor

Marilyn Squalls graduated from Northwestern University in 1980 with a major in chemistry. She has worked for the JOAP Technical Support Center since 1981. While at the TSC, Ms. Squalls has worked in a number of areas including standards production, analytical testing in the JOAP laboratory, the atomic emission spectrometry correlation program, FTIR pilot correlation program, and hydraulics testing. She is a member of the Society of Tribologists and Lubrication Engineers (STLE) and the American Society for Testing and Materials (ASTM).

Filter debris analysis

Course no. 2c | Tues., April 20, 1:00 p.m. | Gary R. Humphrey
$15 | ghumphreys@joaptsc.navy.mil

About the course

We will outline the history, theory, and operation of instrumentation for filter debris analysis and highlight some success stories. Examples of engines diagnosed with problems by FDA will be discussed. Terminology and concepts of energy dispersive x-ray fluorescence (EDXRF) analysis, thin film analysis, and fundamental parameters will be discussed. Basic information will be provided on the operation of an EDXRF system. FDA concepts such as creating initial baseline for equipment, how EDXRF results relate to the metallurgy of an oil system and creating charts to predict possible sources of alloys. Contaminants that can enter an oil system will also be discussed. Basic understanding of oil analysis concepts would be helpful, but not required. This class will be held at the Technical Support Center at the Naval Air Station due to operational requirements and environmental controls. Transportation will be provided to the TSC and back to the conference site.

About the instructor

Gary R. Humphrey is the senior navy chemist at the JOAP Technical Support Center. Mr. Humphrey earned a B.S. in chemistry from the University of Pittsburgh. He was a supervisor of the Navy's oil analysis laboratory for 8 years. During his tenure as a laboratory supervisor he developed criteria linking moisture content of synthetic oil to corrosion metals generated by helicopter gearboxes. Several papers were written and presented on the subject with subsequent award recognition from NAVAIR. Mr. Humphrey joined the JOAP-TSC in 1991 and worked in the areas of particulate contamination measurement and identification. He has authored and published numerous papers detailing particulate contamination measurement and its relationship to wear in machinery. His latest accomplishment has been the development of filter debris analysis using energy dispersive x-ray fluorescence (FDA-EDXRF). Mr. Humphrey developed the FDA-EDXRF procedure; subsequently, the JOAP-TSC was awarded a project by the USAF to build and field test six prototype instruments. Mr. Humphrey was the prime JOAP-TSC recipient for the NAVAIR Commander Fliedner Award.

Infrared spectroscopy and spectral interpretation

Course no. 3a Wed., April 21, 8:00 a.m. Timothy W. Collette, Ph.D.
$15 collette.tim@epa.gov

About the course

Infrared spectroscopy is one of the most practical analytical techniques for identifying simple organic and inorganic chemicals, and also for identifying the functional groups of very complex chemicals and chemical mixtures. However, the power of the approach depends on the ability to manually interpret spectra since libraries typically contain reference spectra of only the most common pure chemicals. (Unfortunately, strategies for spectral interpretation are typically not taught in science degree programs.) This course will include a very brief introduction to the classical theory of vibrational spectroscopy (infrared and Raman), with emphases on how this theory leads to chemical structural elucidation. The "time-honored" approach of group frequency analysis for interpreting infrared spectra will be described using—as examples—the functional groups most commonly encountered in organic chemicals (e.g., CH, C=O, OH, NH, phenyl, etc.).

About the instructor

Timothy W. Collette has been a research chemist at the U.S. Environmental Protection Agency's National Exposure Research Laboratory in Athens, Georgia, since 1985. He received the B.S. degree in chemistry from Berry College (Mount Berry, Georgia) in 1981 and the Ph.D. degree in physical chemistry from the University of Georgia in 1985. Dr. Collette has over 20 years of experience applying infrared and Raman spectroscopy to "real-world" problems, primarily in environmental science. The solution to many of these problems has required in-depth spectral interpretation. For example, he has used infrared spectroscopy, coupled to gas chromatography, to identify previously unknown—and unsuspected—chemical byproducts that are formed when drinking water is disinfected.

Oil analysis on the Digilab FTIR spectrometer

Course no. 3b Wed., April 21, 1:00 p.m. Mike Fuller, Ph.D.
$15 mike_fuller@digilabglobal.com

About the course

This course will discuss the theory and practical applications of infrared spectroscopic methods for the analysis of engine fluids. Infrared techniques have been employed in the analysis of used engine oils since the 1960s. While the basic sampling approaches have not changed radically since that time, the use of automation and advanced chemometric algorithms have extended the value of the analytical approach. With modern instruments more than sixty samples can be analyzed per hour in an unattended mode of operation. This course will discuss the measurement of oxidation, sulfation, residual fuel, soot, glycol, and water in engine fluids. In addition, an approach to measuring total base number (TBN) will be presented.

About the instructor

Mike Fuller is the Chief Technology Officer for Digilab, a provider of products and services in the area of molecular spectroscopy specializing in Raman and infrared spectroscopies. Dr. Fuller earned his Ph.D. in analytical chemistry at Ohio University. After working as the infrared group leader at the R&D Center of Phillips Petroleum for five years he joined Nicolet Instruments. During his time at Nicolet he lead the development of the first dedicated FTIR system for used oil analysis—the Nicolet model 8210. During his time at Nicolet he also was the vice president of marketing and later the vice president of product development. In the summer of 2003 he joined Digilab and is currently, among other activities, the acting product manager for the Digilab oil analysis systems.

Atomic emission spectrometry

Course no. 4a | Thur., April 21, 8:00 a.m. | Edward T. Urbansky, Ph.D.
$15 | eurbansky@joaptsc.navy.mil

About the course

We will begin with basic principles of atomic emission, how atomic spectra arise, and how analytical wavelengths are chosen. Students will learn about the nature of the relationship between concentration and intensity, sensitivity, selectivity, why internal standards are necessary, and how signals are normalized, and how concentrations are calculated. In addition, we will cover practical aspects of accuracy and precision for rotating disk spectrometers using AC arcs. Finally, we will address sources of error and variability and how these can affect the JOAP decision-making process.

About the instructor

Edward T. Urbansky is the physical science department head at the JOAP Technical Support Center. Previously, he was employed at the U.S. Environmental Protection Agency's National Risk Management Research Laboratory in Cincinnati, Ohio, where his research was largely focused on analytical chemistry of drinking water and other aqueous matrixes. Dr. Urbansky earned his B.S. in chemistry from Allegheny College in Meadville, Pennsylvania, and his Ph.D. in chemistry from Purdue University in West Lafayette, Indiana. He has authored or coauthored 46 articles and edited a book, *Perchlorate in the Environment*. Besides serving on a variety of professional committees, he has served in editorial or advisory capacities for several scholarly journals.

Oil analysis on the Spectroil M

Course no. 4b | Thursday, 1:00 p.m. | Bob Yurko
$15 | yurko@spectro.com

About the course

This class provides an overview of the deployment, setup, operation, and routine maintenance of the Spectroil M oil analysis spectrometer in laboratory and field conditions. Emphasis will be on navigating OilM® Windows software for routine analysis. This seminar provides an opportunity for general questions and answers as well as applications assistance for using the Spectroil M in the Joint Oil Analysis Program. Students will have an opportunity to gain hands-on experience with the spectrometer.

About the instructor

Bob Yurko has been the vice president of engineering at Spectro, Inc., since 1988. Mr. Yurko has been responsible for much of the research and development of Spectro's instrumentation and technology currently in use by the Defense Department's Joint Oil Analysis Program and the tribology industry today. He joined Spectro Incorporated in 1981 after working 10 years in the field of spectroscopy for Baird Corporation's government systems division where he had primary responsibility for analytical applications and worldwide field engineering management. He received an associate's degree in computer science from Pennsylvania Technical Institute in 1971. He has authored or co-authored several publications in the field of spectroscopy and analytical techniques. He has served on the ASTM D-2 committee and the American Society of Nondestructive Testing.

Ferrography	Course no. 4c $15	Thursday, 1:00 p.m.	Ray Dalley rjdalley@predictusa.com

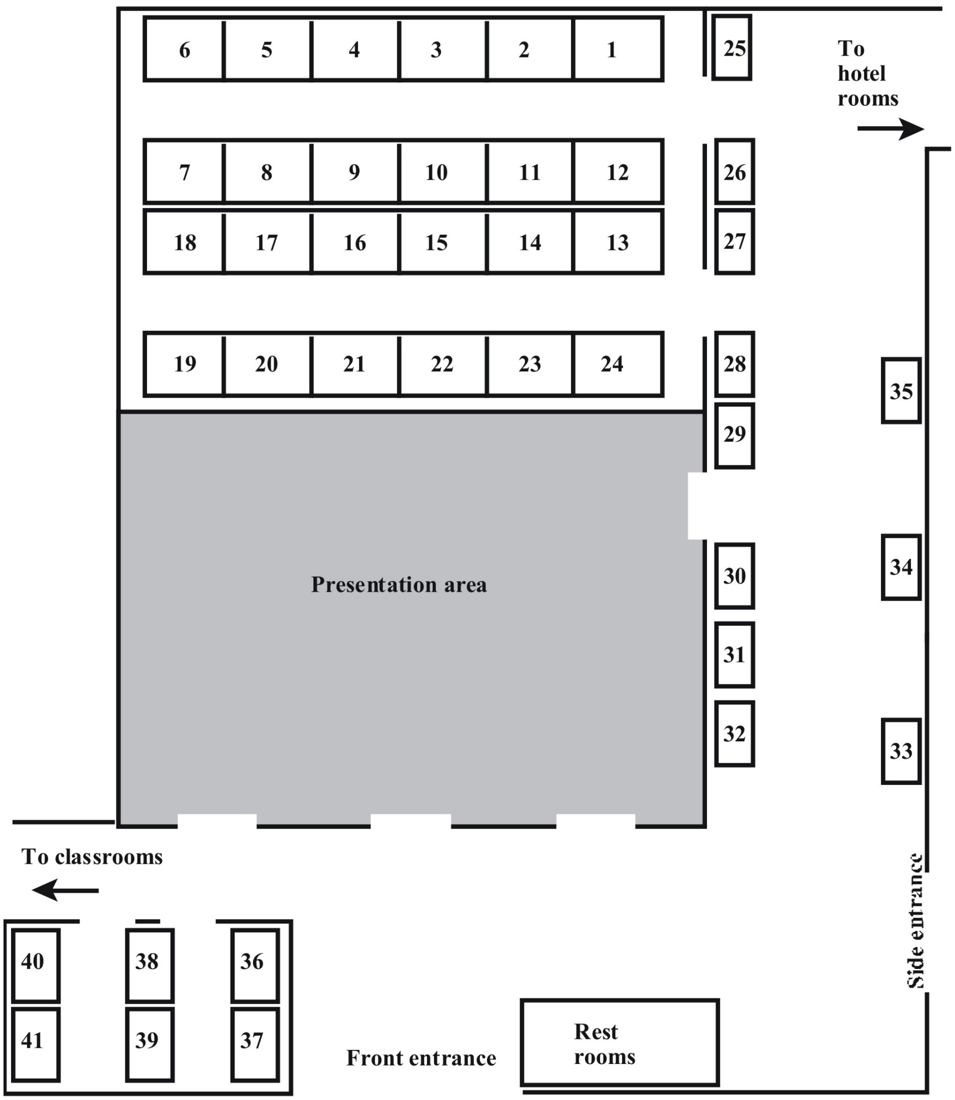
About the course

Students will learn the basics of ferrography and gain hands-on exposure to the instrumentation, from taking the sample, to preparing it, to examining it. We will discuss wear mechanisms and how particles are generated, as well as the characteristics of the particle types that are used to identify and classify them. Finally, we will explore how to combine information obtained via ferrography with that obtained via other methods to assess equipment condition.

About the instructor

Raymond J. Dalley received his mechanical degree from Queensborough Community College and Northeastern Univresity in 1977. He has been involved with researching, manufacturing, selling, and marketing ferrographic equipment for the past 23 years with Predict. Currently vice president for corporate accounts, Mr. Dalley duties include serving as project manager for the ferrographic instrument group, acting as technical liaison to the CEO, and evaluating acquisitions and joint ventures. He lectures globally for a variety of professional technical organizations. Mr. Dalley has published a number of papers about lubricants and wear particle analysis and holds memberships in several professional societies.

CONFERENCE CENTER LAYOUT



Exhibitors

1	Pall Aeropower
2	Gastops
3	Dexsil Corporation
6	Petroleum Systems
7	VHG Labs, Inc.
10	Anton Paar USA
11	R.J. Lee Group
12	Specialty Manufacturing
13	Kittiwake
14	Predict DLI
15	Conostan
16	Thermo Electron
18	DSS
22	PAMAS GMBH
23	Fisher Scientific
24	Thermal-Lube, Inc.
26	Cambridge Applied Systems
27	Digilab
28	UE Systems, Inc.
29	Parker Hannifin
30	Emerson Process Management
33	Hach Ultra
35	Qorpak
36	Merrillsoft
38	U.S. Army Materiel Command Logistics Support Activity
40	Spectro, Inc.
41	Spectro, Inc.

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Make reservations by phone or online.
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12 Via De Luna Drive
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